An Observed Trend in South American Precipitation

INTRODUCTION

The Rio de La Plata basin is the most economically and agriculturally significant river basin in South America, and contains more than half of the continent's population. Popular opinion is that the climate there is changing dramatically, and it is difficult to argue against that proposition. For example, if one estimates flooding by 2 standard deviation (monthly) flow events at Corrientes, Argentina, located at the confluence of the Paraguay and Paraná rivers, there has been a shocking change. There were 6 times as many of these catostrophic events in the 20 years from 1980 to 1999 as there were in the 60 years from 1920-1979, although some of these events have been attributed to the recent strong El Niños. The purpose of the work presented here is to identify trends in South American rainfall and to offer plausible suggestions as to their causes.

DATA

Daily precipitation records from more than 5000 stations are used in this study. Obviously too large values and suspicious runs of 0s are removed. A common problem is that often there is no way to discriminate between '0' and missing.

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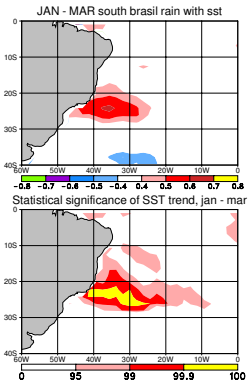
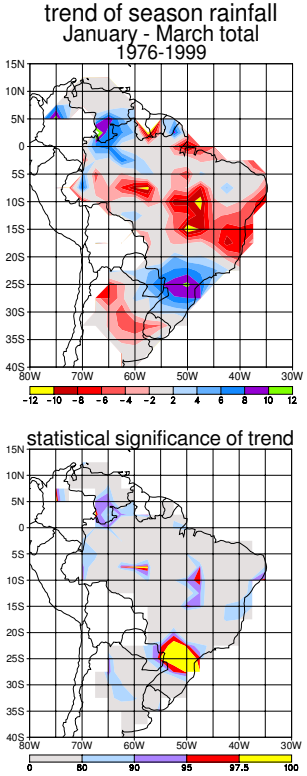
RESULTS

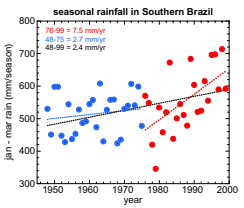
The figure at the right shows the least-squares fit trend in January-March season total precipitation from 1976-1999 (in mm/year). An area in Southeast/Southern Brazil appears as stastically relevant, as judged by randomizations (lower right). South of 20°S, this is the largest observed trend in any 3-month season. The negative trend in central Brazil is largest (and statistically relevant) during December-February. The Southern Brazil trend is a result of an increase in the number of rainy days and in average rainfall on rainy days, rather than on a systematic shift in the timing of the rainy season.

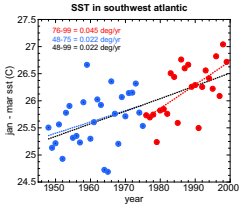
An index is developed by averaging stations within a 2° radius circle of 25°S, 50°W. When this index is correlated with sea surface temperature (SST), the only pattern of significance (on the globe) is off the coast of Brazil (left top). In this area, a positive trend is significant as well (left bottom). The coincidence suggests that the correlation may be due to a trend in both fields.



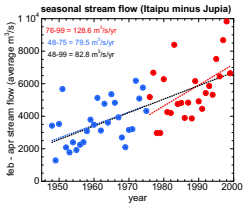


Fortuitously, unlike in most of South America, many records in Southern Brazil begin in the mid-20th century. Using only stations with at least 48 years of data, the trend is seen to be larger in the second part of the record, as it is in SST (below).

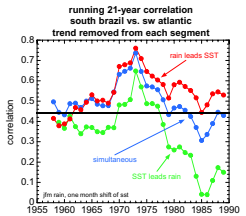




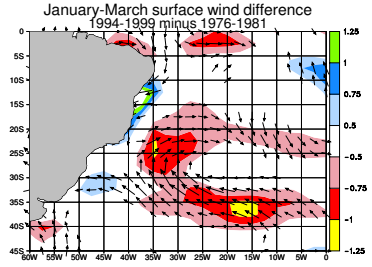
The trend in river flow (index formed by an approximate budget in the area of interest) mirrors that in precipitation, including the increase in trend in the later half of the record (right). The rainfall trend from 1976-1999 in rainfall explains 35% of the interannual variance, and precipitation has increased by 36%. The trend in river flow explains 46% of interannual variance, and flow has increased by 78%.



The trend is removed from each 21-year segment of rainfall and SST (22°S-28°S, 41°W-28°W), and each segment correlated. Significant correlations are evident in the detrended series, especially when SST lags rainfall (left).



The SST trend appears to be a response to a weakening South Atlantic High. The figure at right shows the difference in surface winds (1994-1999 minus 1976-1981) between the first and last 6 years of the recent record. Weakened winds in this area would reduce mixing and coastal upwelling via Ekman transport, resulting in a warming of SSTs.



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CONCLUSIONS

We conclude that a positive trend in Southern Brazil precipitation is related to an SST trend in the nearby southwestern Atlantic, although perhaps not causally. The SST anomalies plausibly are related to a decrease in the strength of the South Atlantic High. The rainfall increase may be related to a change in the preferred phase of a dipole in precipitation that appears on many different time scales. The cause of the trend in the high is not determined, but some have suggested that subtropical highs owe their existence to remote heat sources. We speculate that it is related to an observed trend in the Southern Hemisphere annular mode. It is interesting that the drying trend in eastern Brazil is simulated in a multi-general circulation model experiment run with evolving SSTs.